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Assistive device for people with visual impairments

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Abstract
Sight loss can affect a person's quality of life, independence and mobility and has been associated with injuries from falls and impaired or worsening mental health, problems with social functioning such as finding work and continuing education. Compared to people with normal vision, the visually impaired are at greater risk of depression, anxiety and other psychological problems, and among the visually impaired, those with depressive symptoms report more functional limitations. The need for assistive devices for navigation and orientation has also increased. As an adaptation to the Braille reading system, we wanted to develop an assistive device that would use a smartphone's camera to read a written text.

Keywords: Visual impairments, Rehabilitation, Assistive technologies.

1. Introduction

Advances in technology and better knowledge in the human psycho-physiological perception of 3D worlds enable the design and development of new powerful and fast interfaces to assist people with disabilities.

Vision loss affects patient's ability to work or care for themselves (or others) and affects many activities that would normally be carried out without effort, such as reading, socializing and doing hobbies. Visual impairments make it more difficult to carry out activities of daily living as well as activities specific to an active lifestyle, such as playing sports, shopping, taking medication or driving a car and create certain barriers regarding access to information [1].

According to October 2021 figures from the World Health Organization (WHO) [2], there are an estimated 285 million people with some form of visual impairment globally, of whom 39 million are blind. The authors predict that there will be 48.5 million blind people by 2025 and 115 million blind people by 2050. Undoubtedly, a growing number of people will need solutions or help to improve their quality of life.

Sight loss has a significant impact on the lives of those who suffer from this disability, as well as on their families, friends and society. The complete loss or deterioration of existing vision can be a frightening experience, leaving those affected to question their ability to maintain their independence, their ability to pay for necessary medical care, their ability to keep their place of work and ensure a decent standard of living for themselves and their families [3].The most common causes of visual impairment globally are: refractive errors, cataracts, glaucoma, age-related macular degeneration, corneal pacification, diabetic retinopathy, childhood blindness, trachoma, and idiopathic or indeterminate.

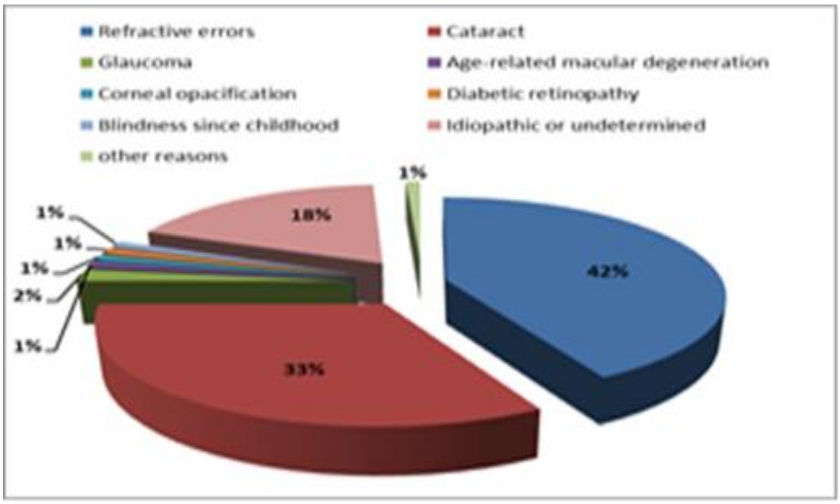

Fig. 1: Causes of visual impairment according to WHO [1].

The simplest and most accessible navigations and tools available are the trained dogs and the white cane [4]. Although these tools are very popular, they cannot provide the visually impaired with all the information and features for safe mobility that are available to the sighted. Most electronic aids that provide services to the visually impaired depend on data collected from the environment (via laser scanner, camera sensors or sonar) and transmitted to the user either by touch, audio or both [5].

Vision rehabilitation is the process of restoring functional capacity and improving the quality of life and independence of an individual who has lost visual analyzer function through disease or injury. Most means of visual rehabilitation are focused on low vision, a visual impairment that cannot be completely corrected by glasses, contact lenses, drugs or surgery. Of the techniques available for vision rehabilitation, most focus on neurological and physical approaches [6].

In physical vision rehabilitation approaches, most of the training focuses on ways to change the environment in which they live and facilitate interaction in it. Occupational therapy is usually recommended for these patients. Occupational therapy is the process of directing human participation towards the performance of certain tasks, with the aim of restoring, supporting and increasing performance, facilitating the learning of those skills and functions essential for adaptation and productivity, reducing or correcting pathological aspects and promotes mental health [7].

There are also devices that help patients achieve a higher level of quality of life [8]. These include virtual magnifiers, peripheral prism glasses that expand the field of vision, direct trans cranial electrical stimulation via electrodes placed on the head, RFID (radio frequency identification) devices, electronic emergency alert systems, virtual sound that helps to perceive the spatial position of an object and smart wheelchairs. Another alternative attitude to solve this problem can be through the use of tactile graphics [9]. Numerous studies indicate that group interventions for older adults with visual impairments are an effective approach in training mobility and developing new methods of self-care at home [10].

The need for devices for rehabilitation and assistance for the visually impaired has increased in recent years. The simplest and most affordable, from a financial point of view, solutions available are specially trained dogs and the white cane. Although these solutions are very popular, they cannot provide the disabled person with all the information for safe mobility or to carry out their daily activities.

All systems, services, devices and appliances that are used by people with disabilities to help them in their daily lives, to facilitate their activities and to carry them out safely, are included under the name of rehabilitation and assistance equipment [11].

Visual assistive technologies are divided into three categories: vision enhancement, vision assistance, and vision replacement. This assistive technology has become available to the blind through electronic medical devices that assist users by detecting and locating objects using sensors and transducers. The sensors also help the user determine the size, height and distance of objects in the environment.

The vision replacement category is more complex than the other two categories because it deals with medical and technological issues. Vision replacement involves displaying information directly on the brain's visual cortex or via optic nerve regeneration. Vision assistance is similar to vision enhancement; however, the result is a non-visual display that can be vibrating, auditory or mixed and can be easily controlled and felt by the visually impaired person [12].

2. Materials and methods

Speaking is a more convenient method of communication than written text, which is why people increasingly use voice search on smartphones, tablets or use voice assistants to find information online [13]. When this becomes absolutely necessary, in the case of visually impaired people, this brings effective integration into the environment in which they live.

It is often impossible for visually impaired people to orient themselves in large spaces and navigate in an unknown area without external assistance [14]. This ability is important for humans to avoid the danger of falls and to change their position, posture and balance. The major obstacles they face are moving up and down stairs, low and high static moving obstacles, wet floors, potholes, lack of knowledge of recognizable landmarks, obstacle detection, object recognition and hazards. These are the major challenges in navigating and orienting indoors and outdoors.

The study aims to make a device that helps the blind people to sail alone by avoiding the obstacles that can be encountered, fixed or mobile, thus preventing any possible

accident.
Our application also uses the phone's camera to read written notes or messages, and to establish an optimal distance and focus, we used a support designed in the Fusion 360 - Autodesk program. The block diagram of the designed prototype is presented in figure 3.

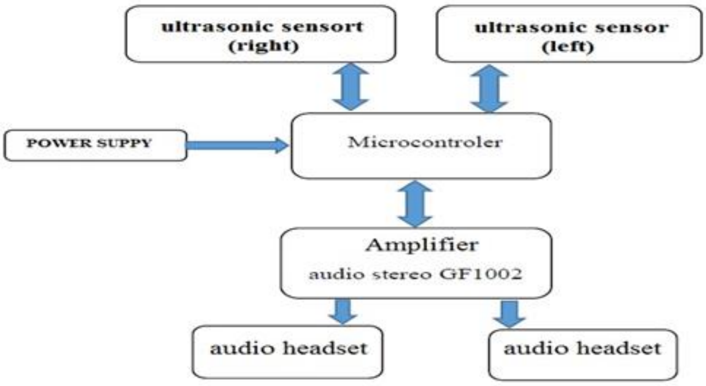

Fig. 2: Block diagram of the prototype system designed

Fig. 3: Block diagram of the prototype system designed

As an adaptation to the Braille reading system and starting from the ideas developed by Shilkrot and collaborators [12], we wanted to design a phone application written in the Java programming language using the Android Studio program, compatible with the Android operating system, composed of two parts: the processing module or OCR (optical character recognition), which recognizes the written characters and the result of which will be a text file; and the second part is the "Text-to-speech" transformation system (from text to speech), the result of which will be an audio file.

2.1 Hardware elements

The study aims to make a device that helps the blind people to sail alone by avoiding the obstacles that can be encountered, fixed or mobile, thus preventing any possible accident. Due to the fact that they have become very important, everyone uses them and owns such a device, the application was chosen to be compatible with a smartphone. So, when retrieving images, the application uses the phone camera of the disabled person and will have permission to use it. During this prototype were used two ultrasound sensors, an ATMEGA128 microcontroller, a stereo GF1002 audio amplifier, a pair of glasses (as a support) and one of the audio headphones. The main component of this work is the HC-SR04 ultrasound sensor, which is used to measure distance to an object using sound waves. The microcontroller collects data, manages sensors on intelligent glasses, detects objects using simple data processing and provides sound warnings to users with visual impairments.

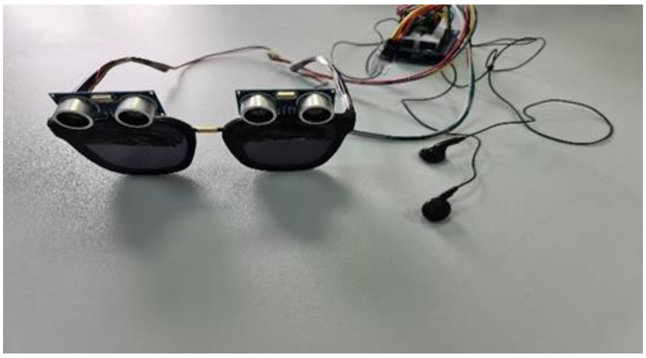

Fig. 4: Hardware prototype

Continuous recording of the distance and the user warning through audio feedback about the distance to the closest object, allows the user to orient in an unknown environment without the support of another person. The second part of the project, to recognize the written messages, is an application developed on the smartphone. The minimum mandatory conditions for the application to be used on the phone are that the device has an Android operating system and has a built-in video camera. After some tests, we found problems when retrieving images. In every digital video camera, there is a lens and a sensor. The autofocus of the phone camera is done using the lens that focuses the light on the sensor in the camera.

Fig. 5: UP - Word "CARTE" (book) at distances of 2, 4 and 12 cm with a font size of 12
DOWN - Word "CARTE" (book) at distances of 2, 4 and 12 cm with a font size of 26

In order for this function (autofocus) to be useful, it is necessary to maintain, for a period of time, a certain distance between the objective and the object of interest, which can represent a major inconvenience in the given conditions. For this purpose, a series of tests were carried out to retrieve the image of a text in different situations. Pictures were taken using the phone camera for the word "BOOK" (in Romanian) at distances of 2 cm, 4 cm and 12 cm, at different font sizes: 13 Times New Roman and 26 Times New Roman. It has been observed that the minimum focusing distance of the phone camera is 3.5 – 4 cm. The results are shown in the figures 5 from above. Thus, for the proper functioning of the application, it is recommended that the images taken by the phone's camera be taken at an optimal focus distance located in the range of 3.5 - 4 cm from the word or words to be read, as it emerged from the tests performed. Therefore, we identified the need to design a phone holder that helps the camera focus at an optimal distance.

We also identified the need to limit the way the paper is positioned (the written information support) with the help of a corner provided with a right angle. The support was made in the Autodesk Fusion 360 program. The file made in this way was exported in ".STL" format with the possibility of being 3D printed using a printer.

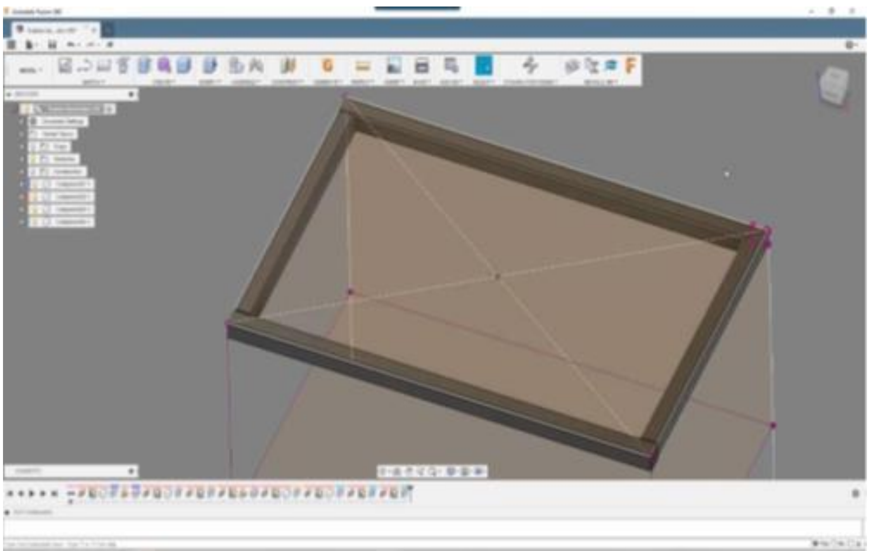

Fig. 6: Stand created in Fusion 360 – Autodesk.

2.2 Software elements

Optical character recognition (OCR) is the mechanical or electronic translation of handwritten, printed, or printed images into editable text. This means that a computer can recognize text on a scanned image using OCR and then convert it to a plain text document. The software component is represented by the OCR processing module developed in the Java programming language with the help of the Android Studio program. Until recently, such Android applications could be made through the Eclipse development environment, together with the ADT (Android Development Tools) plug-in - developed by Google. Relatively recently, Google (the main provider of development tools for Android devices) proposed a new IDE (integrated development environment) - Android Studio, which has the same purpose (to enable the development of mobile applications), but offers more facilities in terms of regarding the installation of the working environment and performance. Android Studio efficiently organizes files according to the most important parts of an Android application ("java" files, "resources", "grade" scripts), according to needs and preferences, this way of representation turned out to be quite practical. The first step of OCR is to use a scanner or camera/video camera to process the physical form of the information. Once the useful information is copied as an image, OCR software converts that information into a two-color (black and white) version. The captured image is analyzed, the dark areas are identified as areas of interest to be recognized and the bright areas are identified as the background. The stages included in the process are the following: The software first does a so-called appearance analysis. To do this, it looks at the layout of the page and separates images from text (if applicable). Also note their position on the page. Then paragraphs are numbered and individual elements such as page numbers are saved. The software analyzes individual blocks of text and breaks them down into sentences. Sentences are then broken down into individual words, and words into letters. This is done with a variable latency (a few seconds) depending on the computing power of the device used. OCR software contains patterns of letters and characters. The program then compares the scanned letters to these patterns. If they are 99% similar, the algorithm decides that it must probably be that letter. It is very accurate because it can compare many patterns in a very short time. In this way, for example, it can successfully differentiate between an "8" and a "B", provided that the resolution at which the photo is taken is also good. Letters and characters are thus gradually recognized. Next comes combining them back into words and putting them back in their place in the sentence. As soon as the software finishes these operations, everything is saved in a normal text document, which can be modified later by users. Next, the text file received from the OCR module will be passed to the Text to Speech transformation module. Today, the accuracy of TTS applications of any kind has reached a rate of 92%, and this is determined by the technology that advances year by year. Text-to-speech (TTS) is a type of assistive technology that reads digital text aloud**.**

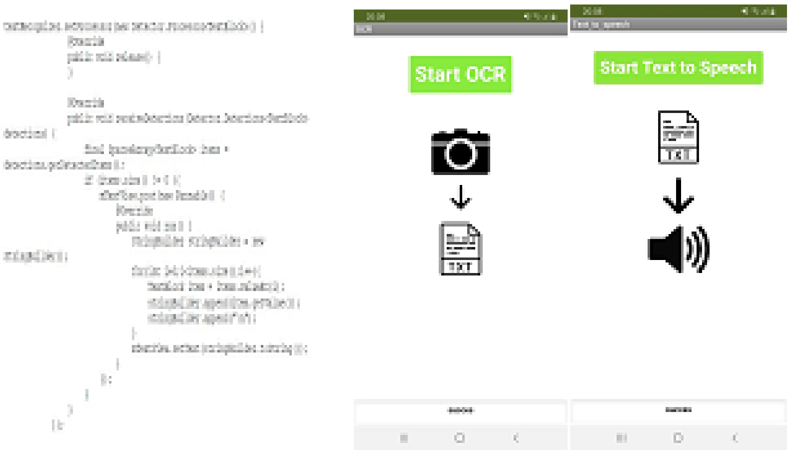

Fig. 7: Code for OCR on the left, on the right the simple interface that accesses the modules developed during the tests.

A combination of text-to-speech (TTS) and Natural Language Processing (NLP) was used in the Voice algorithm used. More specifically, an Application Programming Interface (API) is used that recognizes over a hundred languages and dialects that can be installed on packages due to space considerations. With the help of this algorithm, a text can be transcribed into audio format that can be played later. A combination of text-to-speech (TTS) and Natural Language Processing (NLP) was used in the Voice algorithm used. More specifically, an Application Programming Interface (API) is used that recognizes over a hundred languages and dialects that can be installed on packages due to space considerations. With the help of this algorithm, a text can be transcribed into audio format that can be played later. For efficient operation, the system needs a linguistic database in order to play an audio text file. These databases can be found in the libraries of the Android Studio program, the TTS module does nothing but coherently call these functions.

3. Results & Discussion

The access of people with disabilities to various information is an important aspect of the daily existence of these people with special needs. In the particular case of people with major visual impairments, the information contained in books, magazines, newspapers, brochures offer unprecedented opportunities for an independent lifestyle, the fundamental challenge of any disabled person. There are currently many studies on rehabilitation and assistance equipment for the visually impaired. Developing such a system is a field of research that involves medical, engineering and programming knowledge. In the present work, we designed a hybrid navigation / warning system using ultrasonic sensors to detect obstacles and an application that includes two aspects: the Optical Character Recognition processing module and the Text-to-speech transformation system. At this moment, the application is still in the research and development stage because it was trying to optimize the two presented parts as efficiently as possible. Following the research carried out, a range of main and essential features that the device made to meet:

- The use of innovative technology;
- making a cheap, fast and easy to use device;
- Assembly of the components so that the user does not attract attention and can easily integrate into social environments;
- Use of an independent power source;
- Compliance with the patient's safety rules;
- Permanently recording the distance between object and patient;

- Use of the device by any person, even without higher education in the field.
- We tested the application on the Samsung Galaxy A7 phone (generation 2018).

The presented application prototype that can be used to assist visually impaired people has the following advantages:

- User friendly
- Can be used without the supervision of a personal assistant for persons with disabilities
- Does not have high requirements to be able to be used (a phone compatible with the Android operating system and with a video camera).

4. Conclusions and Discussions

Most medical devices serving the visually impaired depend on data collected from the environment and transmitted to the user through touch, audio, or both. There are different opinions as to which type of feedback is best for this type of device. However, regardless of the services provided by any particular system, there are some basic features required in that system to provide a high level of utility. These characteristics may be the key to measuring the efficiency and reliability of any medical device that provides orientation and locomotion services for the visually impaired. For the user to use this system needs time to accommodate. Although the device detects obstacles at a long distance, it cannot detect objects in the legs (such as border). To solve this problem and to provide maximum safety to the patient, the device should be used with a cane. In the future I want to use this system together with a smart stick that detects obstacles at different levels of height. Following the measured values, it can be seen that the accuracy and reliability of the ultrasonic sensors is good enough to detect distance changes. By applying additional investigations series and changes in this detection system, more information related to distance to the obstacle and the type of obstacle could be provided. An advantage for using the mobile phone in the implementation of the developed idea is the fact that the new generations of phones already have integrated help in the operating system for visually impaired people, which can be helpful for the further development of the system.

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